

TITLE: Binder removal from multilayer ceramic structures

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BSPR:

The debinding process, to avoid deleterious results such as bloating, cracking, low densification, warping, and delamination, is usually conducted at a low rate of heating. Typically the rate of heating does not exceed 5 K/min, which causes undesirably long processing times.

DEPR:

A green module comprised of alumina particles agglomerated by poly(vinylbutyral) binder and containing metal circuitry is placed in a furnace. The furnace may be a conventional batch furnace or a continuous furnace. A continuous furnace should be capable of heating the module and then progressively cooling the module as it travels through the furnace. The continuous furnace should be capable of containing at least two zones of differing atmosphere. A preferred method and apparatus for providing such zones is disclosed in U.S. Pat. No. 4,910,998 entitled "Method And Apparatus For Controlling Flow Bias In A Multiple Zone Process".

DEPR:

Disks with a diameter of 1 inch (2.54 cm) are cut from a tape with a thickness of 0.008 inches (0.15 cm) and a composition of 81.8% alumina, 3.1% kaolin, 5.0% talc, and 10.1% by weight binder/plasticizer comprising poly(vinylbutyral). The disks are stacked twelve layers high and bonded together at a temperature of 90.degree. C. (363K) and a pressure of 5000 psi (3.44.times.10.sup.7 Pa) for 5 minutes. Bonded laminates are individually heated at the rate of 5K/min to 1000 .degree. C. (1273K) in a tube furnace 1.75 inches (2.7 cm) in inside diameter through which passes a gas flow of 10 scfh (79.times.10.sup.6 cubic

of binder and carbonaceous

and typically to about 1825K, where the module is held for the heating, the atmosphere and can be any atmosphere respect to the metal circuitry, is then cooled to the starting

tion has the capability of providing a controlled atmosphere, which may be any atmosphere composed of gases by volume to a temperature 970K. At this temperature, so that the atmosphere remains inert to the metal circuitry, temperature where the chemical reaction between the atmosphere and the metal employed and some additional water is supplied to achieve this condition. This is described in the previous

systems specified an oxygen or limited to oxygen itself, or an oxygen, may be added to a suitable stoichiometric composition of appropriate composition bubbled through a water bath to introduce water. Alternatively as a separate stream of air injected into the gas stream. The atmosphere may be a stream, a hydrogen bearing reducing gas stream which are introduced in the furnace. The feed over a catalyst to achieve a desired composition, prior to a continuous furnace, a stream may be injected at points of the length of the furnace to atmosphere locally.

atmosphere is measured by an inlet to the module, and the heated with the heating of the atmosphere detection element are oxygen concentrations as of water in the aforementioned stream effectively at tempera-

EXAMPLE

Disks (2.54 cm) are cut from a 0.008 inches (0.15 cm) and a 10.1% by weight binder/plasticizer comprising poly(vinylbutyral) tape, twelve layers high and more of 90° C. (363K) and a 5000 psi for 5 minutes. Bonded laminates are heated at the rate of 5K/min to 1000 .degree. C. (1273K) in a tube furnace 1.75 inches (2.7 cm) in inside diameter through which passes a gas flow of 10 scfh (79.times.10.sup.6 cubic

preferably at least 97% of theoretical, and even more preferably at least 99% of theoretical. The sintered functional insert composition is porous after sintering having a density that is less than the density of the sintered surrounding body and preferably about 70% or less of theoretical.

DEPR:

The process of making spray-dried agglomerates from powder metal compositions and the process of compaction, sintering, and infiltration are well known in the art. These processes are described in U.S. Pat. No. 5,686,676 which is hereby incorporated by reference herein. Metal powders are mixed by means of mechanical mixers such as high shear mixers, blenders and mills in the presence of a liquid, preferably water. Once the metal powders are mixed, they can be formed into a compact in any conventional manner. For example, a free flowing agglomerate powder is poured into a die and pressed with either a hydraulic or mechanical press to form a compact. The dimensions of the compact are determined by the size of the desired finished part and the die, taking into account the shrinkage of the compact during the sintering operation. Sintering is preferably accomplished using either a batch furnace or a continuous pusher type furnace. Sintering residence time and temperature depends upon the melting temperature or the eutectic temperature of the metal powder composition. The sintering temperature is greater than at least one metal of the powder metal compositions. Infiltration is well known in the art and metal compositions that are used for infiltration are generally those having a melting temperature of about 1400 deg. C or less.

DEPR:

In yet another embodiment of the invention, the process for making a functionally-graded metal substrate comprises: placing a solid functional insert into the cavity of a solid surrounding body and brazing the solid functional insert to the solid surrounding body. The cavity can be formed by machining the solid surrounding body or by other well-known techniques. The solid, functional insert, preferably a wrought metal, is attached or bonded to

6,114,048

